Vortices in the electron – positron – proton continuum

F. Navarrete[1], R. O. Barrachina[1], J. Fiol[1]

[1]*Centro Atómico Bariloche and Instituto Balseiro*
(Comisión Nacional de Energía Atómica and Universidad Nacional de Cuyo),
R8402AGP S. C. de Bariloche, Río Negro, Argentina.
navarrete@cab.cnea.gov.ar

Vortices are well-recognized features of classical and quantum systems with large numbers of identical particles. Here, however, we are interested in a different kind of vortices that occur in the wave function of a few-body system when considered in the framework of the Pilot-Wave [1] or the Hydrodynamic [2] formulations of Quantum Mechanics.

We conduct a systematic search of vortices in the three-body electron – positron – continuum formed after the ionization of hydrogen by positrons with impact energies E between 0.2 and 2 keV. Vortices formed in the wave function during the collision, might eventually survive up to large times and, according to the imaging theorem [3], would be present in the Transition matrix. Vortices would then manifest themselves as submanifolds of codimension 2, where the ionization matrix element vanishes with a 2π-quantized circulation onto the corresponding normal bundle [4].

Vortices were recently uncovered in (e,2e) processes [5], by means of a C3 calculation with modified Sommerfeld parameters [6] and shown to be related to a deep minimum of the cross section, experimentally observed two decades ago [7]. In order to avoid the complexity posed by the indistinguishability of the projectile and target electrons, a symmetric geometry is usually employed for the study of (e,2e) processes. This is no longer necessary with positrons, where the absence of an exchange contribution makes the analysis of vortices much more direct.

We employ a C3 model in order to investigate the presence of vortices in the ionization of hydrogen by positron impact. These vortices are shown to emerge as pairs of opposite circulation and move apart from each other for increasing values of E. In particular, we demonstrate that they are already present at small and intermediate impact energies where are feasible of being measured with present-day equipments. Finally we discuss their possible observation by means of weak PPS measurements [8].

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